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REVEGETATION AND EROSION CONTROL OBSERVATIONS ALONG THE TRANS-A--ETC(U)
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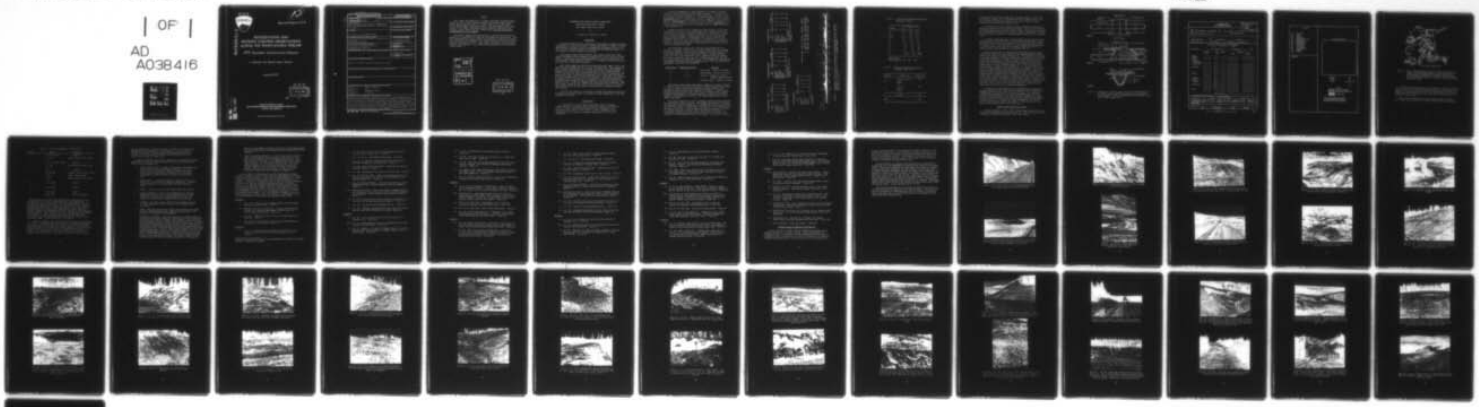

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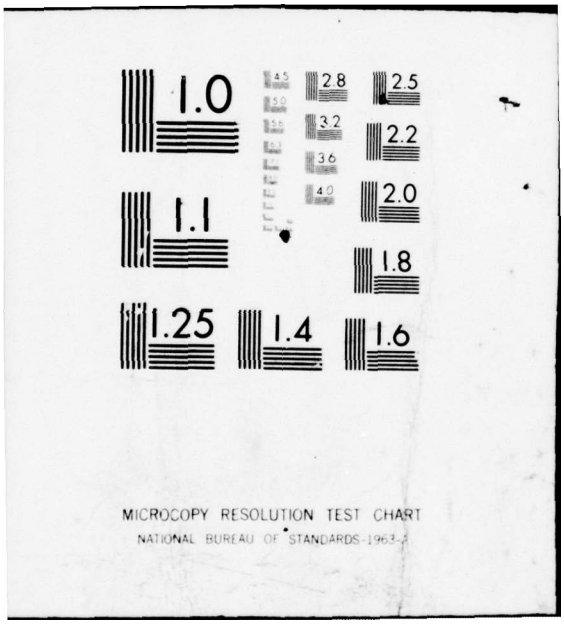
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Special Report 77-8

REVEGETATION AND EROSION CONTROL OBSERVATIONS ALONG THE TRANS-ALASKA PIPELINE

1975 Summer Construction Season

L. Johnson, W. Quinn and J. Brown

March 1977

CORPS OF ENGINEERS, U.S. ARMY
COLD REGIONS RESEARCH AND ENGINEERING LABORATORY
HANOVER, NEW HAMPSHIRE

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Procedures for revegetation and erosion control of the Trans-Alaska Pipeline System during the initial construction phase are reviewed. Fertilizer and seed rates and schedules of application by major areas (sections) are presented. During the field season of 1975 CRREL personnel observed revegetation and erosion control practices along the entire length of the pipeline route. The types of problems and early successes are discussed. Thirty-eight photographs are presented of characteristic areas on which revegetation was initiated. A list of sites for follow up observations is presented.

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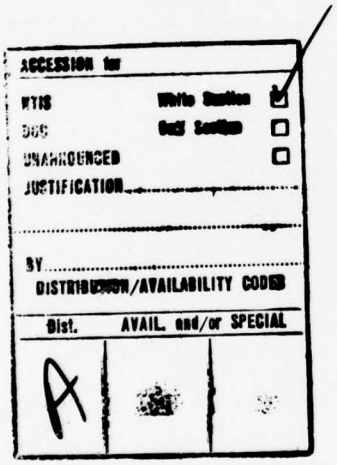
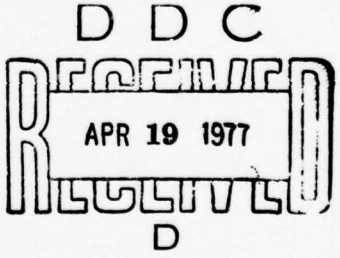
PREFACE

This report was prepared by L. Johnson, Biologist, Alaskan Projects Office; W. Quinn, Chief, Northern Engineering Research Branch, Experimental Engineering Division; and J. Brown, Research Soil Scientist, Earth Sciences Branch, Research Division. The investigations were made as part of the CRREL Trans-Alaska Pipeline Research Program and were primarily funded under DA Project 4A162121AT06, Military Construction and Maintenance in Cold Regions.

The authors express their appreciation to Alyeska Pipeline Service Company for its permission to make the observations reported herein. They also acknowledge the helpful support and information provided by Alyeska field and main office personnel, the Alaska Pipeline Office and the State Pipeline Coordinator's Office. David Gaskin, Geologist, and Kevin Carey, Research Civil Engineer, of the CRREL staff participated in the observational program.





REVEGETATION AND EROSION CONTROL OBSERVATIONS ALONG THE TRANS-ALASKA PIPELINE

1975 Summer Construction Season

by

L. Johnson, W. Quinn and J. Brown

Background

The Trans-Alaska Pipeline, traversing a wide range of climatic, geologic and permafrost conditions, provides a unique opportunity to advance our basic understanding of erosion control and revegetation procedures which in turn will provide a broad data base for evaluating the environmental impact of a wide range of northern construction projects.

The pipeline right-of-way traverses much steeper slopes than normal roads and highways and accordingly the possibility of soil erosion is accentuated. In many areas the underlying permafrost contains large volumes of ice which when thawed causes the weak soil to collapse, accelerating erosion and potentially producing deep gullies.

This report summarizes observations made during the summer of 1975 and admittedly concentrates heavily on erosion problem areas. This emphasis was made to permit documentation of transient situations; invariably remedial measures either have been or will be applied to correct these problems. It is felt that the most useful information obtained from an observational program such as this is derived from knowledge of local problems that develop and the techniques used to resolve these problems. This heavy concentration on problem sites in the report is not intended to infer any proportional correlation with successful and unsuccessful sites along the 800-mile long pipeline route. It was our judgment that those sites which experience long-term success through erosion control and revegetation would be in evidence after several years and that these successes would be reported in subsequent reports.

It is also our intent in this report to present the Alyeska erosion control plan in sufficient detail to provide the reader background on the ALPS strategy in this area.

Introduction

In conjunction with the CRREL Trans-Alaska Pipeline Research Program and under the project entitled "Erosion Control and Revegetation" a series of field observations and office discussions were performed during 1975-76. This report contains a summary of those observations and discussions, and makes suggestions for 1976 field observation.

Pipeline revegetation is viewed primarily as a means of erosion control. However, Alyeska's stated longer term goal is to restore all sites and to facilitate reinvasion of native species. A number of terms are frequently used in reference to the reestablishment of plant cover. Revegetation refers to establishing a cover of vegetation on a disturbed surface. Rehabilitation is a broader term that includes revegetation as well as other techniques to control erosion. Finally, restoration is a long-term process which returns the disturbed site to conditions similar to the original ones.

Alyeska's erosion control program has been proposed in three time-phased field activities. The initial phase, EC-1, takes place during the construction period and applies primarily to areas that are judged to pose erosion problems, although areas that will not be disturbed again can also be seeded. During phase EC-2, or the cleanup period, permanent measures are to be implemented to rehabilitate the construction zone. The third phase, EC-3, involves erosion control maintenance needed to control unanticipated or recurring erosion problems until all sites are ultimately restored.

For construction purposes the route has been divided into six sections or spreads. Each section is further subdivided into alignment sheets which generally cover stretches slightly less than 6 miles long. For example Section 1 between Valdez and Gulkana includes alignment sheets 1-26 while the northernmost section between Toolik and Prudhoe Bay includes alignment sheets 116-138. Alyeska has proposed seed and fertilizer mixtures and application rates to accommodate the geographical and seasonal variations along the pipeline route. For this purpose four geographical zones have been designated:

Seed Mixture	Pipeline Section(s)	Location
1	6	North Slope - Toolik to Prudhoe
2	5	Brooks Range - Coldfoot to Toolik
3	1, 3, 4	Interior - Coldfoot to Valdez (except interior alpine)
4	2	Interior Alpine - Gulkana to Tanana

The planned seed mixtures and seeding schedules are shown in Figure 1. Tables 1 and 2 contain the fertilizer analyses and application rates. In order to account for seasonal variation, seeding schedules were devised that would minimize such problems as winterkill. Specifically, permanent seeding can only occur early in the growing season, followed successively by periods of temporary seeding, no seeding, and dormant seeding. Seeding methods will vary, with hydro-seeding being the most widely used method.

The Alyeska approach has been to predesign rehabilitation procedures and structures to control erosion. The designs are generally restricted to predictable erosion problems and are identified on the Design Drawing Set AL-00-G-10, Sheets 1 through 138. Allowance for local variation and unforeseen conditions is made by permitting Alyeska personnel to modify the standard procedures whenever field conditions necessitate it. Alyeska has prepared an Erosion Control Field Manual to assist field engineers in determining necessary field changes. This manual contains

Interior Alaska, Sections 1, 3 and 4

Seed mixture 3	Tech. spec. 2.9	Pounds/acre Alt. A	Alt. B	Alt. C	Alt. D
Manchar brome*	5	8	5	5	5
Meadow foxtail	12	–	–	–	6
Boreal red fescue†	5	10	9	9	6
Durar fescue	4	5	9	9	6
Sydsport blue	3	3	3	–	3
Nugget blue	–	3	3	6	3
Annual rye	10	10	10	10	10
Total	39	39	39	39	39

* Carlton brome can be used as alternate.
† Pennlawn fescue can be used as alternate.

Interior Alpine area, Section 2

Seed mixture 4	Tech. spec. 2.9	Pounds/acre Alt. A*	Alt. B	Alt. C*	Alt. D
Arctared fescue	10	5	–	5	2
Meadow foxtail	10	–	–	3	1
Sydsport blue	5	6	9	6	9
Boreal red fescue	4	6	10	4	9
Climax timothy†	–	5	4	4	3
Nugget blue	–	5	4	5	5
Blue joint**	–	2	2	2	–
Annual rye	10	10	10	10	10
Total	39	39	39	39	47

* Preferential alternates.
† Engmo timothy can be used as alternate.
** Native species.

Brooks Range, Section 5

Seed mixture 2	Tech. spec. 2.9	Pounds/acre Alt. A*	Alt. B	Alt. C*	Alt. D
Arctared fescue	15	–	15	3	5
Nugget blue	10	15	10	15	15
Climax timothy†	5	5	10	5	5
Meadow foxtail	5	–	–	–	2
Redtop	5	5	5	2	3
Boreal red fescue	5	10	5	10	7
Durar fescue	–	10	–	5	8
Annual rye	15	15	15	15	15
Blue joint**	–	–	–	5	–
Total	60	60	60	60	60

* Preferential alternates.
† Engmo timothy can be used as alternate.
** Native species.

North Slope, Section 6

Seed mixture 1	Tech. spec. 2.9	Pounds/acre Alt. A	Alt. B	Alt. C*	Alt. D*
Arctared fescue	15	–	3	3	10
Nugget blue	10	13	12	10	13
Redtop	5	5	4	5	–
Boreal red fescue	5	5	5	5	5
Durar fescue	–	12	11	10	5
Hair grass†	–	–	–	2	2
Annual rye	15	15	15	15	15
Total	50	50	50	50	50

* Preferential alternates.
† Native species.

Seeding schedule:

Section	Dormant	Permanent	Temporary	No seeding
1,2,3	1 Oct–10 May	10 May–1 Aug	1 Aug–1 Sept	1 Sept–1 Oct
4	15 Sept–1 June	1 June–1 Aug	1 Aug–15 Aug	15 Aug–15 Sept
5	10 Sept–1 June	1 June–15 July	15 July–1 Aug	1 Aug–10 Sept
6	1 Sept–1 June	1 June–15 July	15 July–1 Sept	None

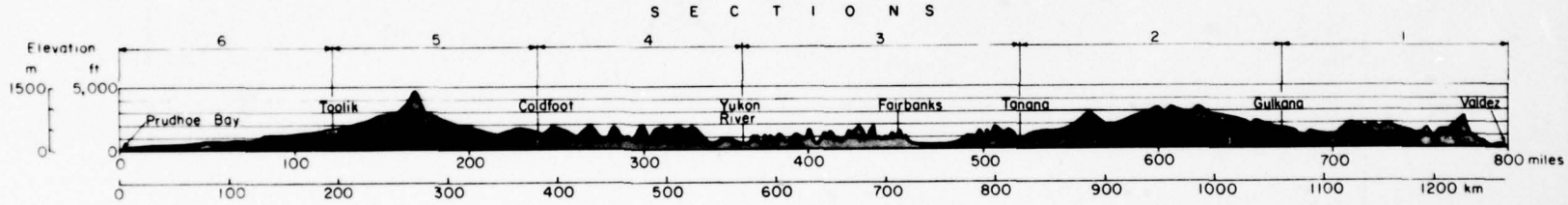


Figure 1. Topographic cross-section of pipeline route showing seed mix and seeding schedules in the six sections. (Source: Alyeska Reports, vol. 1, no. 3, July 1975, p. 10-11.)

Table 1. Fertilizer guaranteed analysis and application rates.

Element	Mixture III	Mixture IV	Mixture V
N	14.1	13.1	10.9
P_2O_5	7.1	14.6	15.1
K_2O	21.3	17.5	14.5
S	5.0	1.3	5.2
Mg	4.2	4.4	3.6
Cu	.49	.36	.36
Zn	.57	.58	.48
B	.14	.14	.12
Mo	.0255	.0262	.0218
Application Rate (lb/acre)	600	600	650

Table 2. Fertilizer application areas by alignment sheet (A.S.)

Mixture	Covers A.S.	Total A.S.
III	1-5, 10, 11, 13 22-39 65-77	39
IV	6-9, 12 14-21 40-64	38
V	78-138	61
Total		138

Erosion Control Procedures (ECPR) which provide guidance on such items as clearing, disposal sites, drainage structures, thermal erosion control, mulches, revegetation, channel lines, fish stream crossings, drainage ditches, and maintenance practices.

In addition to seed and fertilizer mixes, Alyeska has specified a number of additional erosion control procedures. These include the use of mulches such as hay and wood cellulose fiber, tackifiers and excelsior mats, sprigging (the use of woody shrub cuttings), transplants of shrubs and trees, and the spreading of scalped organic materials over disturbed areas.

To protect buried sections of the pipeline from possible erosional damage caused by subsurface water seepage along the pipe trench, about 500 special ditch plugs are planned for use on selected slopes greater than three percent. The plugs consist of an impermeable material which is covered on the uphill side with a granular filter material which permits passage of groundwater to the surface (Fig. 2).

There are generally two Alyeska rehabilitation personnel in each construction section who are responsible for implementing the erosion control plan along the pipeline right-of-way. The revegetation program at the pump stations and terminal facilities is handled by other Alyeska restoration engineers. A record of rehabilitation activities at all sites along the alignment is generally kept in the field office with copies sent to the Anchorage home office for ultimate computerization. These records are kept on "green sheets" (Fig. 3) and can provide a useful source of rehabilitation information. In some sections during the 1975 growing season, green sheets were not available. Green sheets include schematic drawings indicating general field plan views with erosion control structures and procedures indicated. Records are also categorized into rehabilitation activities on such pipeline features as: access roads, airstrips, campsites, material disposal sites, material borrow sites, pipe storage yards, road crossings, river crossings, valve sites and work pads. A specific site may have a number of green sheets associated with it since a new sheet may be used for each follow-up activity. Thus in order to follow the history of a given site, all green sheets for that site are suitably referenced.

In addition to observations of the actual pipeline construction being obtained under this CRREL pipeline research study (including the workpad, material and disposal sites, access roads, and terminals) supplementary information is also being obtained on such associated pipeline related features as the haul road from Livengood to Prudhoe Bay, the Yukon bridge site, and several Alyeska sponsored experimental revegetation sites. Although the Alyeska revegetation and erosion control procedures may not strictly apply to these associated sites, many of these same procedures are being used.

Summer Construction Season (1975)

During the summer of 1975, field reconnaissance observations were made along the entire pipeline route (Fig. 4). Table 3 gives the dates, location, and personnel involved in these observations.

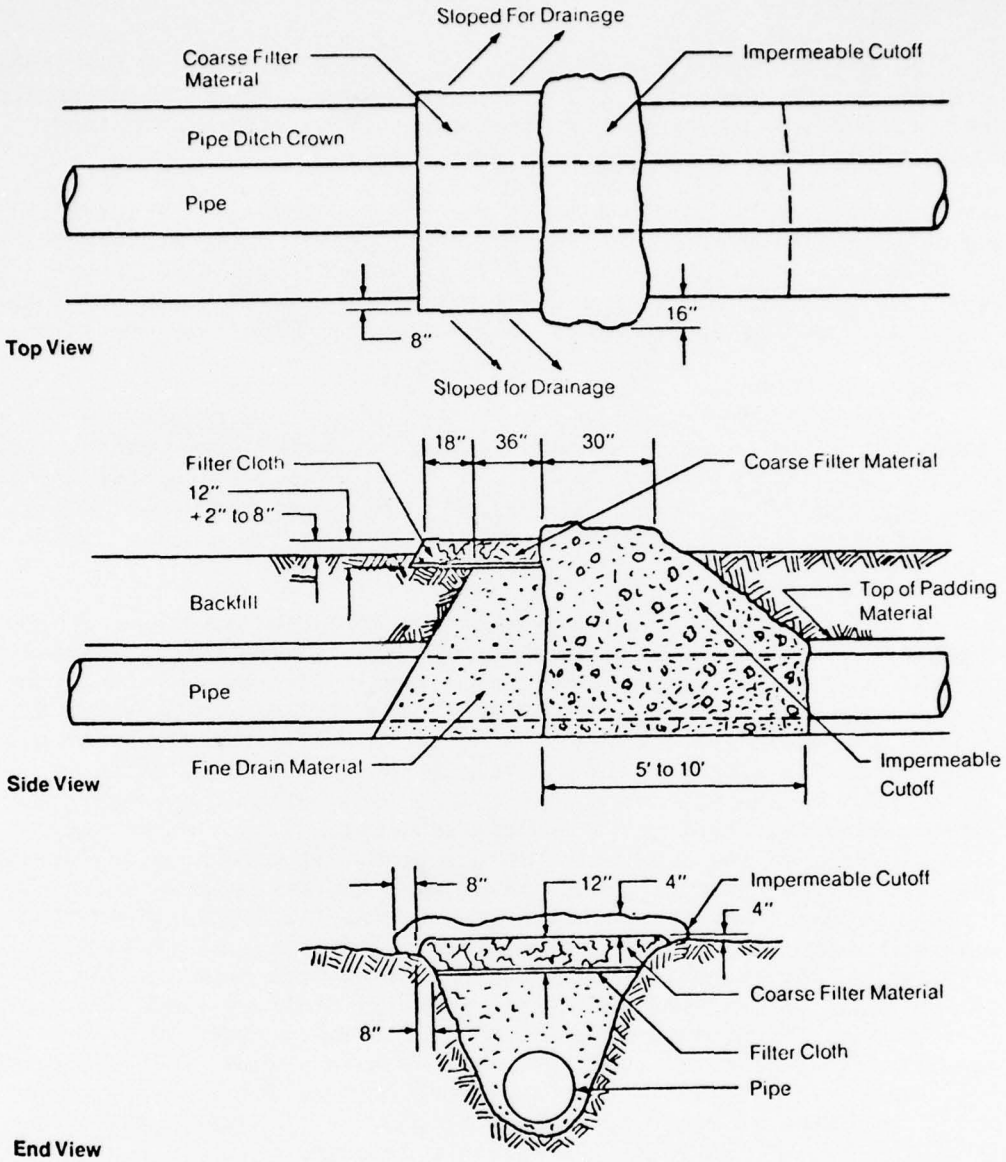


Figure 2. Drawings of pipe ditch plug and typical installation used to protect buried sections of pipeline from subsurface water seepage. (Source: Alyeska Pipeline Data Sheet: Pipe Ditch Plugs, January 1976.)

REHABILITATION AND PLANNING CHECKLIST

FE: _____
CURRENT ACTION
☐ Original
☐ Update
☐ As Built _____ DATE

SITE: _____ _____ ____ ____ _____ _____
(See) (Back) Type and/or Number | Location Name | Sect. | A.S. | From | To
STATIONS (if applicable)

DESCRIPTION & SPECIAL FEATURES: _____

Total Disturbed Area: _____ Acres Exposed SEC Soil: _____ Ownership: _____

DATES: Constr. Start: _____ Use Complete: _____ Permanent Site ☐ Temporary Site ☐

Check one – attach additional sheets for other assessments
☐ EC-1 ☐ EC-2 ☐ EC-3

Est. Start Date: _____ Est. Completion Date: _____ Rehabilitation _____ Acres

	INSTALL. DATE	ECPR NO's	ACRES	MATERIALS TYPE	MATERIALS AMOUNT
Clearing:		1.			
Earthwork:		2.			
Disposal:		3.			
Drainage and Erosion Control:		4.			
Thermal Erosion:		5.			
		5.			
Revegetation: *		6.			
		6.			
		6.			
		6.			
Mulching:		7.			
		7.			
		7.			
Rehabilitation:		8.			
Drainage		9.			
Structures:		9.			
		9.			
Channel Liners:		10.			
		10.			
		10.			
Others:		.			
		.			

Monitor Procedure(s): _____

*Use 6.3D, 6.4D for Dormant Seeding

OFFICE USE ONLY

A/C File No: _____ PERMITS: _____ NTP No.: _____ Field NTP No.: _____

VIE ASSESSMENT: Planned ☐Yes ☐No Completed ☐Yes ☐No Approved ☐Yes ☐No A/C File No. ____
VIE SITE PLAN: Required ☐Yes ☐No Completed ☐Yes ☐No Approved ☐Yes ☐No A/C File No. ____
OTHER IMPACT:

Approved: _____ (Date) _____ (Staff Co-ord.) _____ (Date) _____ (A/C Supv.)

Figure 3
(Source: Alyeska Pipeline Service Company.)

(over)

SITE KEY

AR = Access Road
AI = Airstrip
CP = Camp
DS = Disposal Site
EY = Explosive Storage Yard
MS = Material Site
PY = Pipe Storage Yard
PA = Public Use Area
RD = Road Crossing
RX = River Crossing
TX = Trail Crossing
VZ = Visual Impact Zone
VS = Valve Site
WP = Work Pad

COMMENTS:

SCHEMATIC DRAWING

(Check One)
☐ EC-1
☐ EC-2
☐ EC-3

N
W E
S

LEGEND

Area(s) to be revegetated (includes fertilizer application)

Mulched Area(s)

Provide a simple schematic drawing for the site indicating the general field plans with erosion control structures and procedures.

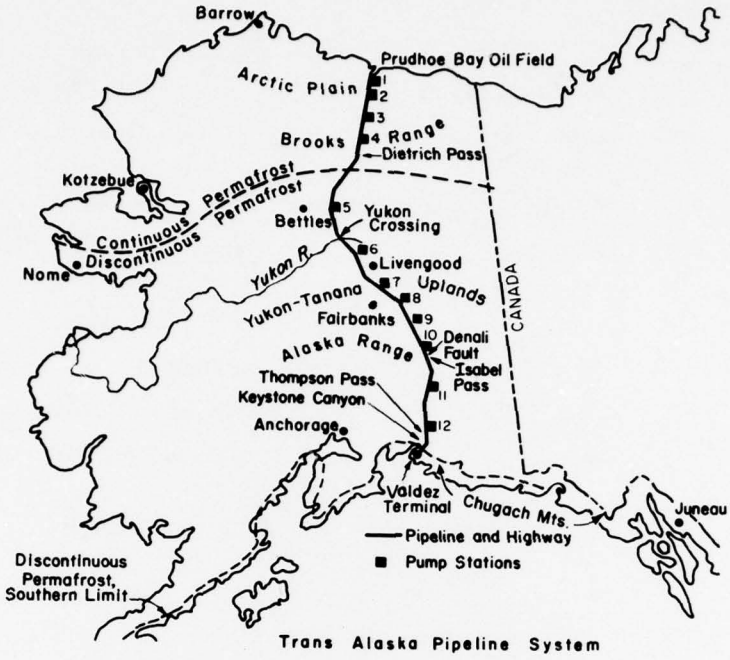


Figure 4. Map of Alaska indicating route of trans-Alaska pipeline system, including pump stations, major and specific physiographic and geomorphic features along the route, and the boundary between the continuous and discontinuous permafrost zones.

Revegetation procedures under a wide variety of situations and the degree of success of the various seeds, fertilizers, and mulches were observed. The reconnaissance provided the opportunity to discuss procedures and results with Alyeska and surveillance personnel along all sections of the pipeline.

Many of the revegetated areas were seeded during the summer of 1975 so that only a portion of a single season's growth was observed.

Table 3. Dates and Locations of Observations

Section	Dates	Personnel
1	17 July, 19 Aug	Johnson
	3, 4 Aug	Brown, Gaskin, Carey, Quinn
2	7, 10, 17 July, 20 Aug	Johnson
	2, 3 Aug	Brown, Gaskin, Carey, Quinn
3	1 July	Johnson
	29, 30 July	Johnson, Gaskin, Carey, Quinn
	1 Aug	Gaskin, Carey, Quinn
	2 Aug	Brown, Gaskin, Carey, Quinn
4	10, 11 Sept	Johnson
5	11, 12 Sept	Johnson
6	16-17 June	Brown
	26-29 July	Brown and Johnson

large number of areas were still under active construction in 1975 and therefore had not been treated during our 1975 observations. A few areas such as the winter haul road, the Livengood-Yukon haul road, and some experimental plots had two or more seasons' growth. These provided some indication of longer-term results. Since revegetation during phase EC-1 is primarily for temporary erosion control, most sections attempted to revegetate only those areas which posed immediate erosion problems. These included road cuts, stream banks, and roadside silt blankets. It was also observed that, in certain instances, revegetation had been attempted on such surfaces as crushed rock or level gravel pads - usually with very little success.

A number of problems associated with the first year of revegetation were noted. It appeared that some areas were not seeded early enough in the growing season. This meant that grasses did not achieve maximum growth and hence, effectiveness for erosion control. In most cases the delay was attributed to late arrival of equipment (hydroseeders, air blowers, etc.) or supplies (seeds, mulch, etc.) or the urgency to complete construction first. Observations during the fall confirmed

that the phenologies (response of plants to climate) of the introduced grasses were very different from the phenologies of native species. This may account for the heavy grazing within revegetated sites by caribou in the north and moose further south which reportedly continued into the winter on some sites.

A number of general observations concerning the revegetation program emerged during these 1975 summer observations; they are listed below along with brief explanations:

1. Growth characteristics: Growth of the grasses was dramatically reduced north of the Brooks Range (Section 6). At sites south of the Brooks Range the extent of growth was usually much greater although heavily influenced by the substrate. This produced a wide variation in growth at these southern sites.

2. Annual cover: In most cases where the vegetation cover was extensive, it was primarily composed of annual rye. Perennial species appeared to be scattered and very much reduced in height.

3. Topsoil: The use of topsoil and organic matter was minimal.

4. Surface preparation: Many of the revegetated sites had been prepared by running cats with deep cleated tracks over them. Germination at these sites occurred primarily in the track depressions where moisture conditions were more favorable.

5. Fireweed: The native species which was most commonly observed to invade revegetated areas along most of the pipeline route was fireweed.

6. Straw: When straw was used as a mulch, oats, barley, and a chenopod often germinated from seeds contained with the straw. The chenopod is an agressive weed elsewhere.

7. Variability in methods: There was variation in restoration methods noted between the various sections. For example, in one section wood fiber mulch was used in low amounts (200 lbs/acre) only as a tracer for hydroseeding, whereas in other sections it was used in much heavier (1500 lbs/acre) application rates as an actual mulch. Some sections extensively used straw mulch whereas other sections made extensive use of wood fiber mulch. Similarly some sections relied heavily on dormant seeding whereas others tried to avoid dormant seeding. At least one section predominantly used aerial seeding while other sections used hand- and hydro-seeding techniques. This variability when superimposed on the already existing climatic and biotic variability gives a complex range of results concerning revegetation. The Alyeska

Erosion Control Manual recognizes the need for field modifications and it is evident that such prerogatives were being taken by field personnel.

8. Impact on existing vegetation: On the arctic coastal tundra a number of impoundments have developed at intersections of the haul road and access roads to the workpad and material sites. This results in flooding of the vegetation and a shift towards aquatic species. At other points along the haul road, the roadside vegetation was covered by dust and oil spray which had been applied to the road surface to help control dust. Finally, there are several instances of diesel oil spills which have contaminated native vegetation communities.

A large number of revegetated sites were observed during summer of 1975. In order to focus attention upon the more important of these, an annotated listing follows. These sites are representative of as wide a range of substrate and latitudinal and altitudinal variation as is possible. It should be recalled that most of the 1975 pipeline revegetation activities and our accompanying photographs were in the EC-1 category, i.e. generally temporary measures in areas that were judged to pose erosion problems, although areas that were not expected to be disturbed again were also seeded. The sites are listed in order from the northernmost (Section 6) to the southernmost (Section 1). Either the alignment sheet number (A.S.), the material site number (M.S.), or other description is given to describe locations. Photographs of most of these locations are contained in the Appendix (Plates 1-39).

Section 6

1. A.S. 131.3: Road cut near Franklin Bluffs airport slumping despite excelsior netting. (Plate 1)

*2. Material sites 127-2.1A and 2.1B: Gravels were hydroseeded but erosion, slumping, development of large cracks, and minimal plant cover persist. (Plate 2)

3. A.S. 122: Happy Valley road cut with ice wedge meltout and slumping. (Plate 3)

4. A.S. 119.1: Slope Mountain material site, hydroseeded and mulched with little growth. (Plate 4)

Section 5

*5. A.S. 114: Seeded disposal blankets along shoulder of road between Galbraith Lake access road and Atigun River cut. (Plate 5)

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*Intensive sites at which CRREL field measurements are proposed to quantify success of revegetation program.

6. A.S. 114: Near vertical road cut hydroseeded and mulched on north side of Atigun River. (Plate 6)

7. A.S. 111 and 112: Hydroseeded gravel pads. (No plate)

8. A.S. 110: A number of seeded and mulched slopes along the northern road approach to Atigun Pass. (Plate 7).

9. A.S. 108: View looking down slump. Stabilized with hay and excelsior matting. (Plate 8).

10. A.S. 108: Revegetated winter trail to east of road. (Plate 9)

11. A.S. 107 (Station 35732): Organic mat folding over road cut. Trees were cut above the road cut to avoid shearing of the slumping organic mat. (Plate 10)

12. A.S. 104 (Station 2809+09): Lush stand of annual rye, along Unnamed Creek bank. Heavily grazed by moose in September. (Plate 11)

*13. Material site 103-0.1: The area at base of Sukakpak Mountain was revegetated but aesthetics may dictate natural vegetation be used instead. Cover 30-80% rye over gravelly substrate. (Plate 12)

14. A.S. 102: Excelsior mats used to stabilize hand seeded cut on east side of work pad; growth mostly annuals. (Plate 13)

15. A.S. 101: Hay mulch and hydroseeded road cut. (Plate 14)

16. A.S. 100: Abandoned and bladed trail was seeded and mulched with hay just north of Middle Fork Koyukuk. (Plate 15)

Section 4

17. A.S. 97: Ice cut exposed by road cut and unseeded as of September 1975. (Plate 16)

*18. A.S. 91: Hydroseeded road cut with overhanging mat and some tussocks and black spruce. (Plate 17)

19. M.S. 91: Material site (AMS-3) probably reseeded in 1974 and having 10-20% cover of annual rye, meadow foxtail, fescue, and fireweed. (Plate 18)

20. A.S. 90: Hydroseeding over weathered granite substrate. (Plate 19)

21. A.S. 88: East side of road cut, one-third of it seeded with good cover in 1975. (Plate 20)

22. A.S. 84: West side of road hydroseeded with wood fiber mulch (beside a stream). Some barley and chenopods germinating from hay. (Plate 21)

23. A.S. 81-82: Winter haul road and east side seeded, just south of No-Name Creek. Cover 10% on organic substrate and 20% on more sandy substrate. (Plate 22)

24. A.S. 80: Roadcut seeded on east side of road north of MS 80-3.1. Germination very low on upper slope. (Plate 23)

Section 3

25. Ice cut at south abutment of Yukon Bridge: Large ice lenses in silt exposed by road cut. Trees left in place on vegetative mat are tearing the mat as they are undercut by thaw. (Plate 24)

*26. Pump Station 6: Large disposal area of wet silt north of station was aerially seeded in May, producing a lush growth of Italian ryegrass. Some areas of coarse gravel shoulder were sparsely seeded using wood fiber mulch. (Plate 25)

27. Mile 20.2 on Haul Road: Experimental plots on road cut treated with urethane foam and plastic nets. (Plate 26)

28. Mile 19.3 on Haul Road: Lower portion hydroseeded. (Plate 27)

29. A.S. 66: MP 418 hydroseeded cut. Workpad was soft; several seeps appeared on work pad surface. Potential problems with icings and groundwater flow down trench. (Plate 28)

Section 2

*30. A.S. 51: Massive sandy slopes in vicinity of Rosa Creek. Hay and netting used to stabilize slopes as well as hydroseeded slopes in pipe storage yard and along access road. (Plate 29)

31. A.S. 48: About 1 mile north of Tanana River, road cuts in ice-rich silt, hydroseeded and hay mulched. Tractor had been run up and down the side slope to produce depressions for holding seed and moisture. (Plate 30)

6. A.S. 114: Near vertical road cut hydroseeded and mulched on north side of Atigun River. (Plate 6)

7. A.S. 111 and 112: Hydroseeded gravel pads. (No plate)

8. A.S. 110: A number of seeded and mulched slopes along the northern road approach to Atigun Pass. (Plate 7).

9. A.S. 108: View looking down slump. Stabilized with hay and excelsior matting. (Plate 8).

10. A.S. 108: Revegetated winter trail to east of road. (Plate 9)

11. A.S. 107 (Station 35732): Organic mat folding over road cut. Trees were cut above the road cut to avoid shearing of the slumping organic mat. (Plate 10)

12. A.S. 104 (Station 2809+09): Lush stand of annual rye, along Unnamed Creek bank. Heavily grazed by moose in September. (Plate 11)

*13. Material site 103-0.1: The area at base of Sukakpak Mountain was revegetated but aesthetics may dictate natural vegetation be used instead. Cover 30-80% rye over gravelly substrate. (Plate 12)

14. A.S. 102: Excelsior mats used to stabilize hand seeded cut on east side of work pad; growth mostly annuals. (Plate 13)

15. A.S. 101: Hay mulch and hydroseeded road cut. (Plate 14)

16. A.S. 100: Abandoned and bladed trail was seeded and mulched with hay just north of Middle Fork Koyukuk. (Plate 15)

Section 4

17. A.S. 97: Ice cut exposed by road cut and unseeded as of September 1975. (Plate 16)

*18. A.S. 91: Hydroseeded road cut with overhanging mat and some tussocks and black spruce. (Plate 17)

19. M.S. 91: Material site (AMS-3) probably reseeded in 1974 and having 10-20% cover of annual rye, meadow foxtail, fescue, and fireweed. (Plate 18)

20. A.S. 90: Hydroseeding over weathered granite substrate. (Plate 19)

21. A.S. 88: East side of road cut, one-third of it seeded with good cover in 1975. (Plate 20)

22. A.S. 84: West side of road hydroseeded with wood fiber mulch (beside a stream). Some barley and chenopods germinating from hay. (Plate 21)

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32. A.S. 42 + 41: Numerous cuts on sides of workpad hydroseeded in alpine area near Donnelly Dome. (Plate 31)

33. A.S. 28: Large pipe storage yard 2-1R north of Hogan Hill. Some erosion gullies despite hydroseeded slopes. Considerable amount of waste silt had flowed toward Haggard Creek in spring. Dikes used to contain waste silt. (Plate 32)

Section 1

*34. Pump Station 11: Massive deep seated slope failure. Failure began about mid June after a period of heavy rainfall. Some additional sliding occurred about mid-July. Seeded latter part of June. (Plate 33)

*35. A.S. 18.1: Ice-rich soils exposed and eroding despite gravel overburden and thick hay mulch. (Plate 34)

36. Material site 17-5: Disposal materials used to cover gravel and then reseeded. Upper area had almost 100% plant cover. (Plate 35)

37. A.S. 16: Steep slope on south side of Squirrel Creek. Some erosion still evident. Wood fiber mulched at 2000 to 2500 lbs/acre. Additional erosion control efforts were planned in 1975. (Plate 36)

38. Disposal site 16-1: Brush covered with soil, wood fiber mulched and reseeded. Reasonable growth by mid summer with willow and fireweed recolonizing. (Plate 37)

39. Material site at milepost 92: Contoured but not seeded during summer 1975. This is an extremely large material borrow site. (No plate)

40. Pump Station 12 - intersection of workpad with highway. Entire width of workpad reseeded over buried pipe. (Plate 38)

41. Valdez Terminal: Areas hydroseeded. (Plate 39)

Proposed Future Revegetation Observations

Future plans for the CRREL pipeline revegetation program include seasonal observations of newly (1975 and current) revegetated and restoration sites. In addition, certain experimental and previously revegetated areas initiated prior to 1975 will continue to be observed. Permanent photograph points either have been or will be established at

the most noteworthy sites. The photographic record of these sites over several years time will help in estimating the degree of success of the particular revegetation procedures used and such important characteristics as overwintering survival. The variety of sites along the entire pipeline route should provide a range of conditions for the evaluation of current revegetation technology in Alaska.

As noted earlier, the several sites indicated by an asterisk will be observed via field measurements to quantify the outcome of the revegetation. The data to be gathered at these sites will include an estimate of the percent cover (1=present, 2=1-5%, 3=6-10%, 4=11-20%, 5=21-40%, 6=41-60%, 7=61-80%, 8=81-100%), the maximum height of the vegetation, and presence or absence of flowering heads. An estimate of the thickness and percent of litter cover will also be made. The native species which invade these sites will be recorded and an estimate made of their abundance. Finally observations on such factors as winterkill, ratio of annual/perennial species, and other pertinent factors will be observed. These measurements will require visits to the intensive sites at least twice during the growing season: at the beginning and at the end.

These periodic observations will provide a quantitative estimate of the rate of restoration along the entire pipeline route. They will also provide information for determining the rate of invasion of the native species and the effect of the introduced species and revegetation techniques upon these invasion rates.

Plate 1. A.S. 131.3: Road cut near Franklin Bluffs airport slumping despite excelsior netting.

Plate 2. Material sites 127-2.1A and 2.1B: Gravels were hydroseeded but erosion, slumping, development of large cracks, and minimal plant cover persist.

Plate 3. A.S. 122: Happy Valley road cut with ice wedge meltout and slumping.

Plate 4. A.S. 119.1: Trail near Slope Mountain material site, hydroseeded and mulched with little growth.

Plate 5. A.S. 114: Seeded disposal blankets along shoulder of road between Galbraith Lake access road and Atigun River cut.

Plate 6. A.S. 114: Near vertical road cut hydroseeded and mulched on north side of Atigun River.

Plate 7. A.S. 110: A number of seeded and mulched slopes along the northern road approach to Atigun Pass.

Plate 8. A.S. 108: View looking down slump. Stabilized with hay and excelsior matting.

Plate 9. A.S. 108-109. Revegetated winter trail to east of road.

Plate 10. A.S. 107 (Station 35732): Organic mat folding over road cut. Trees were cut above the road cut to avoid shearing of the slumping organic mat.

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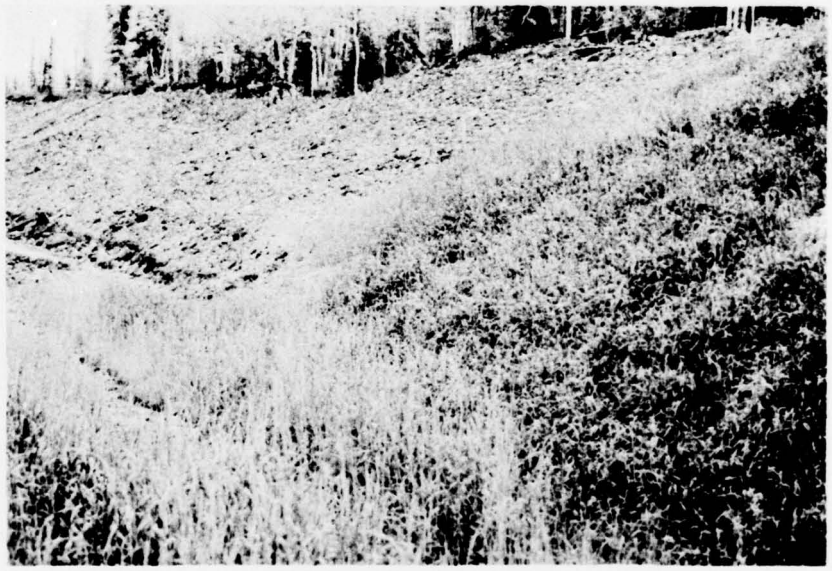

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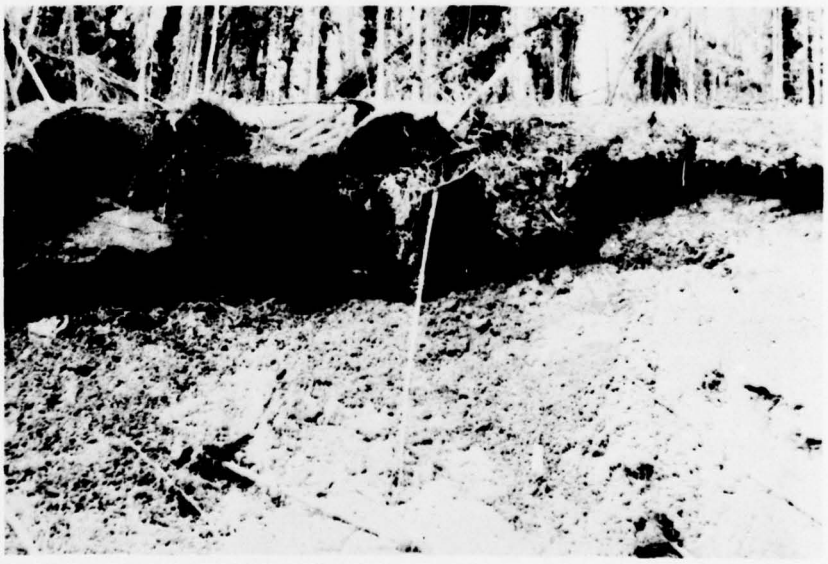

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Plate 25. Pump Station 6: Large disposal area of wet silt north of station was aerially seeded in May, producing a lush growth of annual ryegrass. Some areas of coarse gravel shoulder were sparsely seeded using wood fiber mulch. (Disposal site 77-48.)

Plate 26. Mile 20.2 on Haul Road: Experimental plots on road cut treated with urethane foam and plastic nets.

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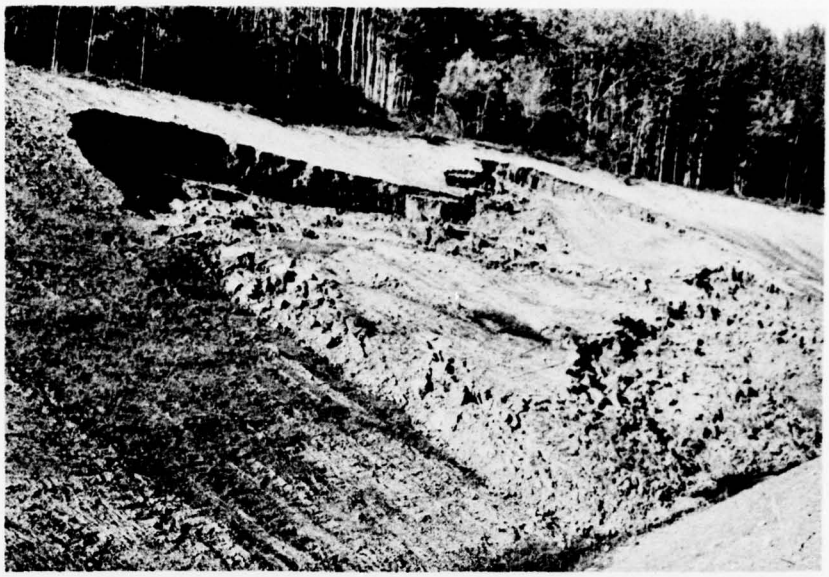

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Plate 38. North of Pump Station 12: Intersection of work-pad with Richardson highway. Entire width of workpad seeded over buried pipe.

Plate 39. Valdez Terminal: Areas hydroseeded.